

TEXAS UTILITIES SERVICES INC.

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Log # TXX-3370  
File # 10010

July 23, 1981

*Mr. Spottswood Burwell*

Mr. Spottswood Burwell  
Licensing Project Manager  
U. S. Nuclear Regulatory Commission  
Office of Nuclear Reactor Regulation  
Washington, D.C. 20555



SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION  
Q032.108 CONTROL SYSTEM FAILURES  
ADVANCE RESPONSE

Dear Mr. Burwell:

Attached is an advance copy of CPSES response to 032.108, Control System Failures. This response shall be inserted into the CPSES FSAR by Amendment 25.

If you have any questions, please call.

Sincerely,

H. C. Schmidt

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cc: ARMS

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The analyses reported in Chapter 15 of the FSAR are intended to demonstrate the adequacy of safety systems in mitigating anticipated operational occurrences and accidents.

Based on the conservative assumptions made in defining these design-basis events and the detailed review of the analyses by the staff, it is likely that they adequately bound the consequences of single control system failures.

To provide assurance that the design basis event analyses adequately bound other more fundamental credible failures you are requested to provide the following information:

- (1) Identify those control systems whose failure or malfunction could seriously impact plant safety.
- (2) Indicate which, if any, of the control systems identified in (1) receive power from common power sources. The power sources considered should include all power sources whose failure or malfunction could lead to failure or malfunction of more than one control system and should extend to the effects of cascading power losses due to the failure of higher level distribution panels and load centers.
- (3) Indicate which, if any of the control systems identified in (1) receive input signals from common sensors. The sensors considered should include, but should not necessarily be limited to, common hydraulic headers or impulse lines feeding pressure, temperature, level or other signals to two or more

control systems.

- (4) Provide justification that any simultaneous malfunctions of the control systems identified in (2) and (3) resulting from failures or malfunctions of the applicable common power source or sensor are bounded by the analyses in Chapter 15 and would not require action or response beyond the capability of operators or safety systems.

ATTACHMENT 3

Proposed Transmittal To Applicants Related To The Concern That  
Common Electrical Power Sources Or Sensors May Cause Multiple  
Control System Failures

ALL OPERATING LICENSE APPLICANTS

SUBJECT: CONTROL SYSTEM FAILURES

The analyses reported in Chapter 15 of the FSAR are intended to demonstrate the adequacy of safety systems in mitigating anticipated operational occurrences and accidents.

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- (3) Indicate which, if any, of the control systems identified in (1) receive input signals from common sensors. The sensors considered should include, but should not necessarily be limited to, common hydraulic headers or impulse lines feeding pressure, temperature, level or other signals to two or more control systems.

- (4) Provide justification that any simultaneous malfunctions of the control system identified in (2) and (3) resulting from failures or malfunctions of the applicable common power source or sensor are bounded by the analyses in Chapter 15 and would not require action or response beyond the capability of operators or safety systems.

R032.108     INTRODUCTION

The evaluation required to answer Question 032.108 consists of postulating failures which affect the major NSSS control systems and demonstrating that for each failure the resulting event is within the bounds of existing accident analyses. The events which are considered are:

- a) Loss of any single instrument.
- b) Break of any single instrument line.
- c) Loss of power to all systems powered by a single power supply system. (i.e. single inverter)

The analysis is conducted for all five major NSSS control systems:

- 1) Reactor control system
- 2) Steam dump system
- 3) Pressurizer pressure control system
- 4) Pressurizer level control system
- 5) Feedwater control system

The initial conditions for the analysis are assumed to be anywhere within the full operating power range of the plant (i.e. 0-100%) where applicable.

The results of the analysis indicate that, for any of the postulated events considered in a) through c) above, the condition II accident analyses given in Chapter 15 of the Comanche Peak FSAR are bounding.

#### LOSS OF ANY SINGLE INSTRUMENT

Table 032.108-1, Loss Of Any Single Instrument, is a sensor-by-sensor evaluation of the effect on the control systems itemized above caused by a sensor failing either high or low. The particular sensor considered is given, along with the number of channels which exist, the failed channel, the control systems impacted by the sensor, the effects on the control systems for failures in both directions, and the bounding FSAR accident. Where no control action occurs or where control action is in a safe direction, no bounding accident is given.

The table clearly shows that for any single instrument failure, either high or low, the condition II events itemized in the FSAR Chapter 15 are bounding.

#### LOSS OF POWER TO AN INVERTER, CONTROL GROUP, OR PROTECTION SET

Tables 032.108-2 through 032.108-5, Loss of Power to Inverters I through IV, respectively, analyze the effects on the control systems caused by the loss of power to an instrument distribution panel. The Comanche Peak NSSS instrument power supply consists of four instrument distribution panels (1A, 2A, 3A, and 4A) receiving power through four inverters (for convenience called inverters I through IV). Each instrument distribution panel powers a single control group and a single protection set (panel 1A,



powered by inverter I, distributes power to control group 1 and protection set I; panel 2A, powered by inverter II, distributes power to control group 2 and protection set II, etc.). Therefore, loss of power to one inverter causes a loss of power to both a protection set and a control group. In the tables, the control systems affected, the sensors affected, the failure direction, the effect on the control systems, and the bounding FSAR accident are given. Where no control action occurs or where control action is in a safe direction, no bounding accident is given.

Besides the loss of the inverter feeding both a protection set and a control group, there is also a chance of losing power to just a control group or a protection set (for example, through the failure of a fuse or circuit breaker). The consequences of a loss of power to a control group or a protection set are tabulated in Tables 032.108-6 through 032.108-9 for losing protection set I, II, III, or IV, respectively, and on Tables 032.108-10 through 032.108-13 for losing control group 1, 2, 3, or 4, respectively. The data is presented in a similar manner to that for the loss of an inverter described in the previous paragraph.

All of the above described inverters, control groups, and protection sets are unique to the NSSS. In addition, there are four inverters that are used for the Balance of Plant (BOP) control system and sensor power. Two of these are Class 1E protection grade (one on each train), while two are non-Class 1E (again, one on each train). These inverters are separate from the NSSS inverters. A loss of power to a Class 1E BOP inverter will disable the steam generator atmospheric relief valves, and cause a feedwater isolation, in two out of four loops (loops 1 and 3 for inverter fed from Train A, loops 2 and 4 for inverter fed



from Train B). A loss of power to a non-Class 1E BOP inverter will block any steam dump to the condenser due to the generation of a condenser unavailable signal. Therefore, the bounding event for a loss of power to any BOP inverter is a Loss of Normal Feedwater (FSAR 15.2.7).

Besides the loss of power to a complete control group or protection set, there is the chance of having an electrical fault on one of the control system circuit cards. The control systems are designed so that each card is used in only one control system. A circuit card failure cannot directly impact more than one control system. A failure on a control card would cause the controller to generate either an "off" or a "full on" output, depending on the type of failure. This result would be similar to having a fault in a sensor feeding the control system. Therefore, the failure of or loss of power in any control system circuit card would be bounded by the Loss of Any Single Instrument analysis described in Table 032.108-1.

The tables show that for a loss of power to any inverter, control group, or protection set, the Condition II events analyzed in the FSAR Chapter 15 are bounding.

#### LOSS OF COMMON INSTRUMENT LINES

Table 032.108-14, Loss of Common Instrument Lines, considers the scenario whereby an instrument line which supplies more than one signal ruptures, causing faulty sensor readings.

Two sets of sensors are located in common lines:

- 1) Loop steam flow (control groups 1 through 4 for steam generators 1 through 4, respectively) and narrow range steam generator level (protection sets I or II, any steam generator)
- 2) Pressurizer level (protection sets, I, II, or III) and pressurizer pressure (protection sets I, II, III, or IV)

Not shown on the tables since they are not part of the plant control system but are used just for protection are the loop flow transmitters. There are three flow transmitters in each loop, with each transmitter having a common high pressure tap but separate and unique low pressure taps. Therefore, a break at the high pressure flow transmitter tap would result in disabling all three flow transmitters in one loop, resulting in a low flow reading for all three transmitters. This would result in a low flow reading for all three transmitters. This would result in a reactor trip if the plant is above the P-8 setpoint, or an annuciation if it is below P-8.

The only malfunction mode explicitly analyzed was a break in the common instrument line at the tap. Another possibility is to have a complete blockage in the sensor tap, causing the sensor to read a constant (before blockage) value. However, this last failure mode is not analyzed since it is really not a credible event. There is no anticipated agent available that would cause a tap blockage. The Reactor Coolant System piping and fittings, and the instrument impulse line tubing are all stainless steel, so no products of corrosion are expected. Also, the

water chemistry is of high quality, which along with high temperature operation, precludes the presence of solids in the water and assures the maintenance of the solubility of chemicals in the water. Therefore, the hypothesis of the presence of a complete blockage of the sensor tap is not sufficiently credible to warrant its consideration as a design basis.

In the extremely unlikely event that a complete instrument line blockage were to occur, the condition is detectable because the reading would become static (no variations over time). In an unblocked channel, a reading would always vary somewhat due to noise (i.e. flow induced noise in flow channels) or slight controller action (i.e. cycling operation of spray and heaters in pressurizer). By a comparison of the static channel to the redundant unblocked channels, the operator would be informed that a blockage in one channel has occurred.

#### CONCLUSIONS

The preceding tables have illustrated that failures of individual sensors, losses of power to inverters feeding control groups and protection sets, or breaks in common instrument lines all result in events which are bounded by FSAR Chapter 15 analyses. Therefore, the FSAR adequately bounds the consequences of these fundamental failures.

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 1 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
Feedpump Discharge Pressure	1 per plant	-----	Feedwater Control	Lo	FW pump speed increases if in auto mode. (FW control valves close due to increased flow if in auto mode.)	If FW pump in manual - no event. If FW pump and FCV in auto - new steady state w/higher pump speed and incr. FCV lift. If FW pump in auto and FCV is manual - bounding event is Excessive FW Flow (FSAR 15.1.2)
				Hi	FW pump speed decreases if in auto mode. (FW control valves open due to decreased flow if in auto mode).	If FW pump in manual - no event. Other modes - result in a decreased FW flow over time, hence bounding event is loss of Normal FW Flow (FSAR 15.2.7).
Steam Header Pressure	1 per plant	-----	Feedwater Control  Steam Dump (TAVG Mode)	Lo	FW pump speed decreases if in auto mode. (FW control valves open due to decreased flow if in auto mode).	If FW pump in manual - no event. Other modes - result in a decreased FW flow over time, hence bounding event is loss of Normal FW Flow (FSAR 15.2.7).

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 2 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
				Hi	FW pump speed increases if in auto mode. (FW control valves close due to decreased flow if in auto mode).	If FW pump in manual - no event. If FW pump and FCV in auto - new steady state w/higher pump speed and decr. FCV lift. If FW pump in auto and FCV in manual - bounding event is Excessive FW Flow (FSAR 15.1.2).
Steam Header Pressure	1 per plant	-----	Feedwater Control Steam Dump (Pressure Mode)	Lo	FW pump speed decreases if in auto mode. (FW control valves open due to decreased flow if in auto mode).	If FW pump in manual - no event. Other modes - result in a decreased FW flow over time, hence bounding event is loss of Normal FW Flow (FSAR 15.2.7).
				Hi	FW pump speed increases if in auto mode. (FW control valve close due to decreased flow if in auto mode). Dump valves open (Steam dump blocked on Lo-Lo TAVG (P-12).)	Steam dump in pressure mode at hot standby or very low power only. Hence, dump valves will open for only a very short time till lo-lo TAVG (P-12) is reached. If FW pump speed is in manual or FW pump and FCV in auto, then this event is bounded by Excessive Increase in Secondary Steam Flow (FSAR 13.1.3). If FW pump in auto and FCV in manual, get increase in FW flow causing excessive cooling. Bounding event is Excessive FW Flow (FSAR 15.1.2).

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 3 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
Loop Steam Flow	2 per loop	1 selected for control	Feedwater Control	Lo	FW pump speed decreases if in auto mode. FW valves close if in auto mode.	If FW pump and FCV in manual - no event. Other modes result in decreased FW flow, bounding event is Loss of Normal FW Flow (FSAR 15.2.7).
				Hi	FW pump speed increases if in auto mode. FW valves open if in auto mode.	If FW pump and FCV in manual - no event. Other modes - result in increased FW flow, bounding event is Excessive FW Flow (FSAR 15.1.2)
Loop FW Flow	2 per loop	1 selected for control	Feedwater Control	Lo	FW valve opens if in auto mode	If FCV is manual - no event. If FCV in auto, result is Excessive FW Flow (FSAR 15.1.2)
				Hi	FW valve closes if in auto mode	If FCV in manual - no event. If FCV is auto, result is decreased FW flow. Bounding event is Loss of Normal FW Flow (FSAR 15.2.7)
Narrow Range Level	4 per Steam Generator (two available I or II for control)	1 selected for control	Feedwater Control	Lo	FW valve opens if in auto mode	If FCV in manual - no event. If FCV in auto, result is Excessive FW Flow (FSAR 15.1.2)
				Hi	FW valves closes if in auto mode	If FCV in manual - no event. If FCV is auto, result is decreased FW flow. Bounding event is loss

## CPSES/FSAR

TABLE 032.108-1

## LOSS OF ANY SINGLE INSTRUMENT

(Sheet 4 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
						of Normal FW Flow (FSAR 15.2.7)
Pressurizer Level (Control)	3 per plant	I or III	Prz. Level Control	Lo	Charging flow increases. Heaters turn off (except for local control). Letdown isolated (VCT empties, charging pumps take suction from RWST.)	Bounding event is Increased Reactor Coolant Inventory (FSAR 15.5.2)
				Hi	Charging flow decreases Backup heaters on (Later, letdown isolation from interlock channel, heaters blocked from interlock channel.)	While heaters are on, no net depressurization of RCS. After heaters are blocked, decreased charging flow acts to depressurize RCS. Depressurization event is therefore bounded by Inadvertent Opening of a Pressurizer Safety or Relief Valve (FSAR 15.6.1)
Pressurizer Level (Interlock)	3 per plant	II or III	Prz. Level Control	Lo	Letdown isolated. Prz. heaters blocked (except for local control). (Charging flow reduced to maintain level).	Steady-state reached at slightly high level. No event.
				Hi	No control action, set Hi level annunciation.	Not applicable
Pressurizer Pressure	4 per plant	I	Prz. Pressure Control	Lo	Turn on Backup Heaters. PORV 455A blocked from opening.	Heaters being on causes increase in Prz. pressure to PORV 456



## CPSES/FSAR

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 5 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
			(Pos. 1 or 2)		PORV 456 opens if required, closes when pressure falls below dead band. Spray remains off.	actuation. No event.
				HI	PORV 455A Opens, closes when pressure falls below deadband. Spray turned on.	Result is bounded by Inadvertent Opening of a Prz. Safety or Relief Valve (FSAR 15.6.1)
			(Pos. 3)*		Channel not connected	
Pressurizer Pressure	4 per plant	II	Prz. Pressure Control (Pos. 2 or 3)	Lo	No control action. PORV 456 blocked from opening. PORV 455A Opens if required, closes when pressure falls below deadband.	Not applicable
				HI	PORV 456A Opens, closes when pressure falls below deadband.	Result is bounded by Inadvertent Opening of a Prz. Safety or Relief Valve (FSAR 15.6.1)
			(Pos. 1)*		Channel no connected	Not applicable
Pressurizer Pressure	4 per plant	III	Prz. Pressure Control (Pos. 3)*	Lo	Turn on Backup Heaters. PORV 455A and 456 blocked from opening. Spray remains off.	Heaters being on causes increase in Prz. pressure, possibly to safety valve actuation. No event.

## CPSES/FSAR

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 6 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
				Hi	PORV 455A Opens, closed on low pressure interlock. Spray turned on. PORV 456 unblocked.	Result is bounded by Inadvertent Opening of a Prz. Safety or Relief Valve (FSAR 15.6.1)
			(Pos. 1 or 2)*	Lo	Block PORV 456 from opening; no control action	Not applicable
				Hi	Unblock PORV 456; no control action	Not applicable
Pressurizer Pressure	4 per plant	IV	Prz. Pressure Control (Pos. 1)*	Lo	Block PORV 456 & 455A from opening; no control action	Not applicable
				Hi	PORV 455A unblocked. PORV 456 opens, closes when pressure falls below deadband.	Result is bounded by Inadvertent Opening of a Prz. Safety or Relief Valve (FSAR 15.6.1)
			(Pos. 2 or 3)*	Lo	Block PORV 455A from opening; no control action	Not applicable
				Hi	Unblock PORV 455A; no control action	Not applicable
TAVG	one per loop	Any	Steam Dump (TAVG Mode) Auct. Reactor Control	Lo	Stop turbine loading, defeat remote dispatching (C-16 Annunciation occurs).	Not applicable

## CPSES/FSAR

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 7 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
			Hi	Prz. Level Control		
			Auct. Lo	Turbine Loading/Dispatching		
				Hi	Rods in (safe direction). Charging flow increases until full power Prz. level is reached (if at reduced power). If reactor trips, steam dump enabled and dump valves open until steam dump stops when Lo-lo TAVG is reached.	No event unless reactor trips, then dump valves open and bounding event is Excessive Increase in Secondary Steam Flow (FSAR 15.1.3)
TAVG	one per loop	Any	Steam Dump (Pressure Mode)	Lo	Stop turbine loading, defeat remote dispatching (C-16) (Annunciation occurs).	Not applicable
			Auct.	Reactor Control		
			Hi	Prz. Level Control		
			Auct. Lo	Turbine Loading/Dispatching		
				Hi	Rods in (safe direction). Charging flow increases until full power Prz. level is reached (if at reduced power).	dy-state reached at full power pressurizer level. No Event.
Steamline	3 per loop	Control	Steam Dump	Lo	No control action	Not applicable

## CPSES/FSAR

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 8 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
Pressure	for protection Channel 1 per loop for control (different from those used for protection)			Hi	S. GEN. relief valve opens.	Bounding event is Inadvertent Opening of a Steam Generator Relief or Safety Valve (FSAR 15.1.4)
Intermediate Range Flux	2 per plant	I or II	Reactor Control	Lo	No control action.	Not applicable
				Hi	Reactor trips.	Not applicable.
Turbine Impulse Chamber Pressure (Control)	2 per turbine	I (Pos. 1)* I (Pos. 2)*	Steam Dump (TAVG Mode) Reactor Control FW Control	Lo	Rods in (safe direction), auto rod withdrawal blocked (C-5). (If reactor trip occurs, steam dump unblocked and dump valves modulate until no load TAVG is reached). No effect on FW control since have constant S.G. level program.	Not applicable
				Hi	Rods out until blocked by Hi flux, overpower, or overtem- perature, rod stop, or until programmed TREF limit is reached. (If reactor trip occurs, steam dump unblocked and dump valves	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2)

## CPSES/FSAR

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 9 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
					open until no load TAVE is reached). No effect of FW control since have constant S.G. level program.	
Turbine Impulse Chamber Pressure (Control)	2 per turbine	I (Pos. 1) I (Pos. 2)*	Steam Dump (Pressure Mode) Reactor Control FW Control	Lo	Rods in, (safe direction) auto rod withdrawal blocked (C-5). No effect on FW control since have constant S.G. level program.	Not applicable
				Hi	Rods out until blocked by Hi flux, overpower, or overtem- perature rod stop. (If reactor trip occurs, dump valves open to to keep steam header pressure at or below setpoint). No effect on FW control.	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FCA 15.4.2)
Turbine Impulse Chamber Pressure (Interlock)	2 per turbine	II (Pos. 1)* I (Pos. 2)*	Steam Dump (TAVG Mode)	Lo	Unblock steam dump	Not applicable
				Hi	Block steam dump.	Not applicable
Turbine Impulse	2 per turbine	II (Pos. 1)* I (Pos. 2)*	Steam Dump (Pressure Mode)	Lo or Hi	No control Action.	Not applicable

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 10 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
Chamber Pressure (Interlock)						
Power Range Flux	4 per plant	Any	Reactor Control FW Control	Lo	No control action (auctioneered Hi)	Not applicable
				Hi	Auto and manual rod withdrawal blocked (C-2), rods in (in safe direction). FW bypass valve opens if in auto. (If reactor trip occurs, dump valves open until no load TAVG is reached). Rising S.G. level causes valve to close till steam and feed flow are matched	Steady-state reached with higher S.G. level. No event.
Condenser Available	2 per condenser	Any	Steam Dump	Lo	No control action-steam dump unblocked, condenser available.	Not applicable
				Hi	No control action-steam dump blocked, condenser unavailable.	Not applicable
TAVG High Auctioneer	1 per plant	-----	Steam Dump Reactor Coolant Prz. Level Control	Lo	Steam dump blocked (TAVG mode). Charging flow decreased till no-load level reached. Rods out, power increases until blocked	Result is bounded by Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power (FSAR 15.4.2)

## CPSES/FSAR

TABLE 032.108-1

LOSS OF ANY SINGLE INSTRUMENT  
(Sheet 11 of 11)

<u>SENSOR</u>	<u>NUMBER OF CHANNELS</u>	<u>FAILED CHANNEL</u>	<u>SYSTEM</u>	<u>ASSUMED FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING EVENT</u>
					by high flux, overpower, or overtemperature and stop.	
				Hi	Identical to TAVG channel failing high, see analysis above.	See above
Steam Flow Pressure Compensator	2 per loop	Control Channel	Steam Flow	Lo	Identical to Loop Steam Flow channel failing low. See analysis above.	See above
				Hi	Identical to Loop Steam Flow channel failing high. See analysis above.	See above

\* Signals for pressurizer and turbine impulse chamber pressure can be obtained from different channels. Selection of desired channels is done by manual switches in the control room. Resulting accident due to failed instrument is dependent on switch positions.



## LOSS OF POWER TO INVERTER I (Sheet 1 of 1)

(Loss of Power to Protection Set I and Control Group 1)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	All (System Deenergized)	Off/Closed	No initiating event, steam dump system unavailable.	
Reactor Control	Power Range Flux (Control) Turbine Pressure (Control TAVG (Loop 1)	Low  Low  Low	Rods in, power decreases. Stop turbine loading/defeat remote dispatching	Loss of FW flow (FSAR 15.2.7) event is bounding since increased charging flow/ isolated letdown has little effect relative to the decreased feed flow. (Reactor trip would occur on S.G. low-low level.
FW Control (S.G.1) and PUMP Speed Control	All System Deenergized)	FW Valve closes in S.G.1. Pump speed decreases (auto mode only)	Loss of main FW in S.G.1 (Plant trips on low S.G.1 level) Other loops have decrease in FW flow due to decreased pump speed.	
Pressurizer Level	Pressurizer Level (Control)	Low	SW pos. 2 or 3 - Charging flow increases, heaters blocked, letdown isolated. SW pos. 1 - channel not connected, no control action.	
Pressurizer Pressure	Pressurizer Pressure (PORV 455A)	Low	SW pos. 1 or 2 - Spray off. PORV 455A stays closed. PORV 456 available if needed. SW pos. 3 - Channel not connected, no control action.	

## CPSES/FSAR

TABLE 032.108-3

## LOSS OF POWER TO INVERTER II (Sheet 1 of 2)

(Loss of Power to Protection Set II and Control Group 2)

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	Turbine Pressure (Interlock)	Low	No control action, steam dump unblocked.	
Reactor Control	Power Range Flux Turbine Pressure (Interlock and Control) TAVG (Loop 2)	Low Low Low	Rods in, power decreases, stop turbine loading/defeat remote dispatching.	Loss of FW flow (FSAR 15.2.7) event is bounding for similar reasons as for Loss of Inverter I. Reactor trip will occur on S.G.2 low-low level.
FW Control	All in S.G.2 (System Deenergized)  Steam Flow Pressure Compensation	FW Valve Closes  Low	Loss of main FW in S.G.2. (Plant trips on low S.G.2 level).  If steam flow pressure compensation obtained from Protection Set II, get decrease in main FW in affected loop.	Increased FW flow in other SGs due to low level signal would be partially compensated by steam/FW mismatch signal, so total loss of FW would be more severe event.
FW Control (SG 1,3 and/or 4) (If switch allows reading SG level from Protection Set II)	Narrow Range Level	Low	FW valve opens, flow increases	

## CPSES/FSAR

TABLE 032.108-3

## LOSS OF POWER TO INVERTER II (Sheet 2 of 2)

(Loss of Power to Protection Set II and Control Group 2)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Prz. Level	All (System Deenergized)	Low	Charging flow off, letdown isolated, heaters blocked.	
Prz. Pressure	Pressurizer Pressure (PORV 456)	Closed	SW pos. 2 or 3 - No control action, PORV 456 stays closed, PORV 455A available if needed. SW pos. 1 - channel not connected, no control action.	

## CPSES/FSAR

TABLE 032.108-4

## LOSS OF POWER TO INVERTER III (Sheet 1 of 1)

(Loss of Power to Protection Set III and Control Group 3)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	None	--	No signals affected, no control action.	
Rod Control	Power Range Flux TAVG Loop 3	Low Low	Stop turbine loading/defeat remote dispatching	Loss of FW flow (FSAR 15.2.7) event is bounding for similar reasons as for Loss of Inverter 1. Reactor trip will occur on S.G.3 low-low water level
FW Control (S.G.3)	All (System Deenergized)	FW Valve closes	Loss of main FW in S.G.3. (Plant trips on low S.G.3 level.)	
Prz. Level	Pressurizer Level (Control or Interlock)	Low	SW pos. 1 - charging flow increases, heaters blocked, letdown isolated. SW pos. 2 - no control action, channel not connected. SW pos. 3 - Heaters blocked, letdown isolated. (Charging flow reduces to maintain level.	
Prz. Pressure	Pressurizer Pressure (PORV 456 Interlock) PORV 455A Control)	Low	SW pos. 1 or 2 - No control action, PORV 455A stays closed, PORV 456 available if needed SW pos. 3 - PORV 455A and 456 stay closed, backup heaters on (if allowed by level interlock), spray off.	

TABLE 032.108-5

## LOSS OF POWER TO INVERTER IV (Sheet 1 of 1)

(Loss of Power to Protection Set IV and Control Group 4)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	Auctioneered TAVG	Low	No initiating accident, low TAVG prevents activation of steam dump.	
Rod Control	All (System Deenergized)	Low	No control action, no rod motion.	Loss of FW flow (FSAR 15.2.7) event is bounding since turning on of pressurizer heaters is temporary and transient effects are slow-reacting in comparison with loss of FW. (S.G.4 tripped on low-low water level.)
FW Control (S.G.4)	All (System Deenergized)	FW Valve Closes	Loss of main FW in S.G.4. (Plant trips on low S.G.4 level.)	
Prz. Level	Auctioneered TAVG	Low	Any SW pos-turn on all backup heaters. Charging flow reduced till no-load level reached. (Spray turned on when pressure rises to lower setpoint due to heaters).	
Prz. Pressure	Pressurizer Pressure (Interlock)	Low	SW pos. 1 - No control action; both PORVs stay closed. SW pos. 2 or 3 - No control action, PORV 455A stays closed.	

TABLE 032.108-6

LOSS OF POWER TO PROTECTION SET 1  
(Sheet 1 of 1)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	Turbine Pressure (Control or Interlock)	Low	If affected turbine pressure signal on control channel, steam dump demanded but blocked from interlock. If on interlock channel, no control action and steam dump unblocked. (If reactor trips, steam dump performs as designed.)	
Reactor Control	Power Range Flux (Control)	Low	If Turbine pressure on control channel, rods in (safe direction), power decreases and stop turbine loading/defeat remote dispatching. Otherwise, no control action.	Bounding event is either Excessive FW Flow (FSAR 15.1.2), or Loss of Normal Feedwater Flow (FSAR 15.2.7), depending on channels used. Increased charging flow and pressurizer transients have little effect in comparison.
	Turbine Pressure (Control)	Low		
	TAVG (Loop 1)	Low		
FW Control	Narrow Range Level (Any Loop)	Low	If affected level signal used for control, FCV opens in affected loop, FW flow increases (overrides steam flow signal). Otherwise, channel not connected, get decreased FW flow for loops with failed steam flow pressure compensation only. No effect on remaining loops.	
	Steam Flow Pressure Compensation (Any Loop)	Low		
Pressurizer Level	Pzr. Level (Control)	Low	If affected level signal used for control, charging flow increases, letdown isolated, heaters blocked. Otherwise, channel not connected,	

## CPSES/FSAR

TABLE 032.108-6

LOSS OF POWER TO PROTECTION SET I  
(Sheet 2 of 2)

CONTROL SYSTEMS <u>AFFECTED</u>	SIGNALS <u>AFFECTED</u>	FAILURE <u>DIRECTION</u>	ITEMIZED <u>EFFECTS</u>	BOUNDING <u>EVENT</u>
			no control action.	
Pressurizer Pressure	Pzr. Pressure (PORV 455A)	Low	If affected pressure signal used for control, PORV 455A stays closed, back-up heaters on (but could be blocked on level signal, see above). Spray off. (PORV 456 available if required.) Otherwise, channel not connected, no control action.	



TABLE 032.108-7

LOSS OF POWER TO PROTECTION SET II  
(Sheet 1 of 2)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	Turbine Pressure (Control or Interlock)	Low	If affected turbine pressure signal on control channel, steam dump demanded but blocked from interlock. If on interlock channel, no control action and steam dump unblocked. (If reactor trips, steam dump performs as designed.)	Bounding event is either Excessive FW Flow (FSAR 15.1.2), or Loss of Normal FW Flow (FSAR 15.2.7), depending on channels used.
Reactor Control	Power Range Flux (Control)	Low	If turbine pressure on control channels, rods in (safe direction), power decreases and stops turbine loading/defeat remote dispatching. Otherwise, no control action.	
	Turbine Pressure (Control)	Low		
	TAVG (Loop 2)	Low		
FW Control	Narrow Range Level (Any Loop)	Low	If affected level signal used for control, FCV opens in affected loop, FW flow increases (overrides steam flow signal). Otherwise, channel not connected, get decreased FW flow in loops with failed steam flow pressure compensation only. No effect on remaining loops.	
	Steam Flow Pressure Compensation (Any Loop)	Low		
Pressurizer Level	Pzr. Level (Interlock)	Low	If affected level signal used for interlock, block heaters and isolate letdown. Otherwise, channel not	

TABLE 032.108-7

LOSS OF POWER TO PROTECTION SET II  
(Sheet 2 of 2)

CONTROL SYSTEMS <u>AFFECTED</u>	SIGNALS <u>AFFECTED</u>	FAILURE DIRECTION	ITEMIZED <u>EFFECTS</u>	BOUNDING <u>EVENT</u>
			connected, no control action.	
Pressurizer Pressure	Pzr. Pressure (PORV 456)	Low	If affected pressure signal used for control, PORV 456 stays closed. (PORV 455A available if required.) Otherwise, channel not connected, no control action.	

## CPSES/FSAR

TABLE 032.108-8

LOSS OF POWER TO PROTECTION SET III  
(Sheet 1 of 1)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	None	---	No signals affected, no control action.	
Reactor Control	Power Range Flux (Control) TAVG (Loop 3)	Low Low	No control action due to auctioneers.	Combining effects of pressurizer level and pressure control systems, could have either increasing charging flow with heater off causing a depressurization, or else heaters cause pressure to increase until PORV 455A is actuated, or until safety valve opens. Either way, event is bounded by Inadvertent Opening of a Pressurizer Safety or Relief Valve (FSAR 15.1.2)
FW Control	None	---	No signals affected, no control action.	
Pressurizer Level	Pzr. Level (Control or Interlock)	Low	If affected level signal used for control, charging flow increases, letdown isolated, heaters blocked. If used for interlock, heaters blocked and letdown isolated. Otherwise, channel not connected, no control action.	
Pressurizer Pressure	Pzr. Pressure (Interlock and Control)	Low	PORV 456 stays closed. If affected pressure signal used for control, PORV 455A stays closed, backup heaters on (if allowed by level signal, see above) and spray off. Otherwise, PORV 455A available if required.	

TABLE 032.108-9

LOSS OF POWER TO PROTECTION SET IV  
(Sheet 1 of 1)

CONTROL SYSTEMS <u>AFFECTED</u>	SIGNALS <u>AFFECTED</u>	FAILURE <u>DIRECTION</u>	ITEMIZED <u>EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	None	---	No signals affected, no control action.	
Reactor Control	Power Range Flux (Control) Tavg (Loop 4)	Low  Low	No control action due to auctioneers.	
FW Control	None	---	No signals affected, no control action.	No event is initiated due to loss of power, therefore bounding event is not applicable.
Pressurizer Level	None	---	No signals affected, no control action.	
Pressurizer Pressure	Pzr. Pressure (Control and Interlock)	Low	PORV 455A stays closed, PORV 456 available if needed. If affected pressure signal used for control, PORV 456 also stays closed.	

TABLE 032.108-10

LOSS OF POWER TO CONTROL GROUP 1  
(Sheet 1 of 1)

CONTROL SYSTEMS AFFECTED	SIGNALS AFFECTED	FAILURE DIRECTION	ITEMIZED EFFECTS	BOUNDING EVENT
Steam Dump	All (System Deenergized)	Off/Closed	No initiating event, steam dump system unavailable. (If reactor trip occurs, S.G. atmos. relief valves available.)	
Reactor Control	None	---	No signals affected, no control action.	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7). (Plant trips on low level in S.G. 1).
FW Control (S.G.1) and FW Pump Speed Control	All (System Deenergized)	FW Valve Closes, Pump Speed Decreases (Auto mode only)	Loss of main FW in S.G.1. If FW pump in auto mode, pump speed decreases causing FCV to open in S.G.2, 3, and 4. (Plant trips on low level in S.G.1)	
Pressurizer Level	None	---	No signals affected, no control action.	
Pressurizer Pressure	Pzr. Pressure (PORV 455A Control) Spray and Heater Actuation	Closed  Off	No initiating event, PORV 455A remains closed, heaters and spray remain off. (PORV 456 available if needed.)	

## CPSES/FSAR

TABLE 032.108-11

LOSS OF POWER TO CONTROL GROUP 2  
(Sheet 1 of 1)

CONTROL SYSTEMS <u>AFFECTED</u>	SIGNALS <u>AFFECTED</u>	FAILURE <u>DIRECTION</u>	ITEMIZED <u>EFFECTS</u>	BOUNDING <u>EVENT</u>
Steam Dump	None	---	No signals affected, no control action.	
Reactor Control	None	---	No signals affected, no control action.	
FW Control (S.G.2)	All (System Deenergized)	FW Valve loses	Loss of main FW in S.G.2 (Plant trips on low level in S.G.2.)	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7) (Plant trips on low level in (S.G.2.)
Pressurizer Level	All (System Deenergized)	Off	Charging flow off, letdown isolated, heaters blocked.	
Pressurizer Pressure	Pzr. Pressure (PORV 456 Control)	Closed	No initiating event, PORV 456 remains closed. (PORV 455A available if needed.)	

## CPSES/FSAR

TABLE 032.108-12

LOSS OF POWER TO CONTROL GROUP 3  
(Sheet 1 of 1)

CONTROL SYSTEMS <u>AFFECTED</u>	SIGNALS <u>AFFECTED</u>	FAILURE <u>DIRECTION</u>	ITEMIZED <u>EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	None	---	No signals affected, no control action.	
Reactor Control	None	---	No signals affected, no control action.	
FW Control (S.G.3)	All (System Deenergized)	FW Valve Closes	Loss of main FW in S.G.3 (Plant trips on low level in S.G.3.)	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7) (Plant trips on low level in (S.G.3.)
Pressurizer Level	None	---	No signals affected, no control action.	
Pressurizer Pressure	Pzr. Pressure (PORV 455A Interlock)	Closed	No initiating event, PORV 455A remains closed. (PORV 456 available if needed.)	



TABLE 032.108-13

LOSS OF POWER TO CONTROL GROUP 4  
(Sheet 1 of 1)

<u>CONTROL SYSTEMS AFFECTED</u>	<u>SIGNALS AFFECTED</u>	<u>FAILURE DIRECTION</u>	<u>ITEMIZED EFFECTS</u>	<u>BOUNDING EVENT</u>
Steam Dump	Auctioneered TAVG	Low	No initiating event, steam dump system unavailable. (If reactor trip occurs, S.G. atmos. relief valves available.)	
Reactor Control	All (System Deenergized)	Off	Rods stay stationary	
FW Control	All (System Deenergized)	FW Valve Closes	Loss of main FW in S.G.4. (Plant trips on low level in S.G.4.)	Bounding event is Loss of Normal FW Flow (FSAR 15.2.7) since decreased charging flow has little effect in comparison. (Plant trips on low S.G.4 level.)
Pressurizer Level	Auctioneered TAVG	Low	Charging flow decreases till no-load pressurizer level reached.	
Pressurizer Pressure	Pzr. Pressure (PORV 456 Interlock)	Closed	No initiating event, PORV 456 remains closed. (PORV 455A available if needed.)	

TABLE 032.108-14

LOSS OF COMMON INSTRUMENT LINES (Sheet 1 of 1)  
(ASSUMED BREAK IN LINE)

<u>SENSORS</u>	<u>FAILED CHANNELS</u>	<u>SYSTEM</u>	<u>FAILURE DIRECTION</u>	<u>EFFECT</u>	<u>BOUNDING ACCIDENT</u>
Loop Steam Flow and Narrow Range Level	I or II	Feedwater Control	Lo Hi	FW valve closes in affected S.G., pump speed decreases	Bounding event is Loss of FW Flow (FSAR 15.1.2)
Pressurizer Level (Control) and Pressurizer Pressure (PORV 455A)	I (Level and Pressure)	Prz. Level Control Prz. Pressure Control	Hi Lo	PORV 465A stays closed. Spray unavailable. Charging flow decreases (Control). Backup heaters on (Control). (On low level, letdown isolated and heaters blocked from interlock channel).	This is a depressurization event, which is bounded by inadvertent opening of a Prz. Safety or Relief Valve (FSAR 15.6.1).
Pressurizer Level (Interlock) and Pressurizer Pressure (PORV 456)	II (Level and Pressure)	Prz. Level Control Prz. Pressure Control	Hi Lo	No level control action. PORV 456 stays closed.	Not applicable.
Pressurizer Level (control or Interlock) and Pressurizer Pressure (Either PORV)	III (Level) III and IV (Pressure)	Prz. Level Control Prz. Pressure Control	Hi Lo	PORV 455A and 456 stay closed. Spray unavailable if on Channel III. Charging flow decreases and backup heaters on if on control channel. No control action from level interlock. (On low level, letdown isolated and heaters blocked from non-failed channel, either control or interlock).	Depending on switch positions, event is at most a depressurization event which is bounded by inadvertent opening of a Prz. Safety or Relief Valve (FSAR 15.6.1).